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NEW LABORATORY METHODS FOR INSTRUCTION IN GEOGRAPHY

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I. MAP AND MODELING APPARATUS[1]

Map contours, the notation of physiography. Until the student has become familiar with the idea and use of surface contours as employed on hypsometric maps, a very large part of the field of physiography remains closed to him. He is in the position of the student of music who is unfamiliar with musical notation. Thus in a strict sense he is debarred from making use of the great reference libraries of physiography; the topographic atlas sheets, until he has acquired the language in which they are printed. Some students, and those especially who possess what the Germans term *Vorstellungsgabe,* and we *visualizing power,* move rapidly toward an intelligent use of the map. Others will require every aid which can be afforded them before the grammar even of the subject is acquired. For many it will only be necessary to read with care the excellent and remarkably clear statements concerning the manner in which contours

[1] The greater part of this paper was first published in *School Science and Mathematics* in October, 1908. An outline of the subject was presented in August before the International Geographical Congress at Geneva, Switzerland; and although at that time in type for the pages of *School Science,* a request came from the editor of the *Scottish Geographic Magazine* to reprint it, and it accordingly appeared in that journal in December, 1908. Immediately upon the appearance of the paper in the last mentioned journal came a request from the editor of the JOURNAL OF GEOGRAPHY to allow it to be reprinted in the January number of this journal. Inasmuch, however, as the apparatus described had, in the meantime, been much improved, the paper is here republished with new cuts representing the later form, and with considerable modifications and additions to the text. The second part of the original contribution, which related to laboratory methods in geology, by request of the editor will appear in a succeeding number of this journal in a similarly modified form.—THE AUTHOR.

express elevation, which appear upon the inside of the covers of the United States Geologic Folios. Obviously it is not for such students that the aids hereinafter to be described were especially designed, though it is thought that even for them individual laboratory study with the apparatus will be distinctly advantageous.

Precise vs. accurate maps. A topographic contour map being always an approximation only to the correct representation of the configuration of the country, it may be described in terms (1) of the measure in which it assumes to approach a correct delineation, and, (2) the measure of warrant for the degree of correctness assumed. These contrasted ideas are embodied in the terms precision and accuracy. The measure of precision is afforded by the map in its scale and in its contour interval. A map printed on the scale of two inches to the mile and with a contour interval of ten feet, makes larger assumptions than one printed on the scale of two miles to the inch and with a contour interval of one hundred feet. Though more precise, the former may be no more accurate than the latter. Assuming, however, that the map has been intelligently, skillfully, and conscientiously made, its accuracy will depend chiefly upon how many points there are upon the map whose position and elevation have been determined, since these are the basis upon which the contours have been sketched.

Method of preparing maps. In the case of the most accurate of contour maps, the engineer by means of his transit locates and fixes the altitude of a very large number of points. He notes at each of these, or at such points as seem necessary for his purpose, the direction and the angle of the slope. Contour lines, representing as they do points on the same level, are horizontal, and hence at right angles to the direction of slope. The map makers' task is, therefore, completed by drawing his contour lines perpendicular to the lines of steepest slope, and at such distances from the points already located as the altitudes and angles of slope at each of the latter require. The simple apparatus to be described aims to put the student in the position of the engineer who makes the map, and when the map has been completed, to apply a simple test of its accuracy from the use of which the actual map maker is debarred.

Map and modeling apparatus for laboratory use—the tank. The apparatus for the purpose consists of a tank made from galvanized iron which is one foot square upon the bottom and five inches in depth (See Fig. 1), with a flange or rim at the top. On each of two opposite sides this rim is provided with a scale graduated into inches and quarters of an inch, and the distance between these flange scales may be accurately

adjusted by screw bolts which work in slots at the corners of the tank. The tank is further provided with a brass faucet on one side, set low enough to empty it of water to one-half inch from the bottom. A vertical scale four inches in length and graduated into half inches is set within the tank at the back, and short lines are provided on the three remaining sides of the tank at a height of four inches above the bottom. It is thus possible to roughly level the tank when filled with water to this depth. The vertical gauge is

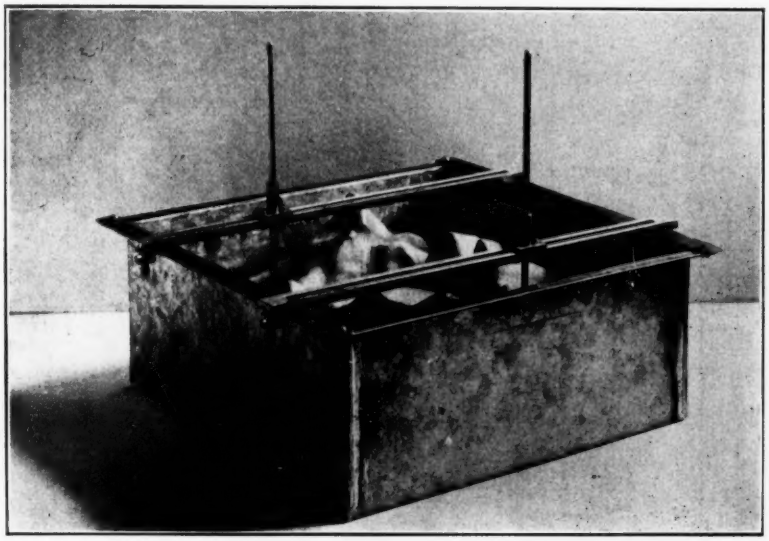


FIG. 1. General View of Map and Modeling Apparatus

provided to permit of withdrawing water from the uppermost mark in successive half-inch layers.

The measuring attachment. The measuring attachment to the apparatus is simply a device for fixing the position in terms of three rectangular coördinates of any point within the tank. This attachment consists of three parts, namely, (a) *the sliding track,* (b) *the locating carriage,* and (c) *the altitude gauge,* all of which are made from brass and plated.

The sliding track (See Figs. 1, 2 and 5) consists of two brass bars one-quarter inch square in cross-section, which are joined at the ends through an intermediate short piece of the same material separating the two from each other and leaving a slot between them one-quarter inch in width and of the full length of the tank. The attachment when laid across

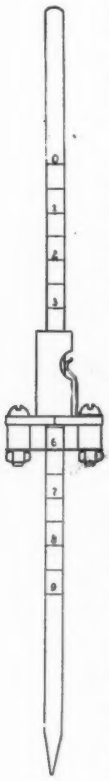


Fig. 2
The locating carriage and altitude gauge

the tank from the graduated flange on one side to that upon the other, projects beyond each by about one quarter of an inch. A post fitted with thread and screw nut is set upon the under side and at each end of the attachment, so that it may be clamped to the flange in any desired position. It is thus a simple matter to slide the track to any required position (providing only it is kept parallel to the ungraduated rims of the tank), and there to clamp it firmly. The sliding track thus serves to fix definitely and in succession a series of parallel sections across the tank. For fixing the position of the locating carriage, a graduation into inches and quarters of an inch is borne upon one side of the sliding track.

The locating carriage, whose form and construction will be sufficiently clear from Fig. 5, is of brass and moves easily along the attachment to any desired point, determined by the graduation upon the track. The purpose of the carriage is to supply a second coördinate in the measurement and thus to complete the *location* in the *plan* of any point which is within the tank.

The altitude gauge (See Figs. 2 and 5) is a bar of brass of circular cross section brought to a dull point at its lower end and graduated into quarters of an inch. A simple spring in the locating carriage supports it at any desired altitude within the limits of its length, and the graduation is so made that when the point of the gauge rests upon the bottom of the tank the reading is zero. When at an altitude of one half an inch the reading is 1, when at one inch the reading is 2, etc. The normal contour interval for the gauge is therefore one half inch, though it can, if desired, be made one fourth inch.

Models of typical land forms. Mr. Irving D. Scott, instructor in Physiographical Geology at the University of Michigan, has prepared a series of six waterproof plaster models adapted for use in connection with the above described apparatus. Each of these models is made eleven inches square, so as to fit easily within the tank and also be easily removed (See Fig. 3). Care has been taken that the amount of relief in these models is such as to secure the best results, and the details of the modeling are made relatively simple. When not in use with the map apparatus this series of models serves to illustrate typical land forms for classes in physical geography. A series of models used in this way are: 1, a mesa and dis-

sected plateau; 2, a river flood plain with terraces; 3, an embayed coast; 4, Scottish glens (glacier-carved valleys); 5, a group of drumlins; 6, a group of volcanoes.

Use of the apparatus in map making. To prepare a contour map of any desired model, the latter is placed on the bottom of the tank, and

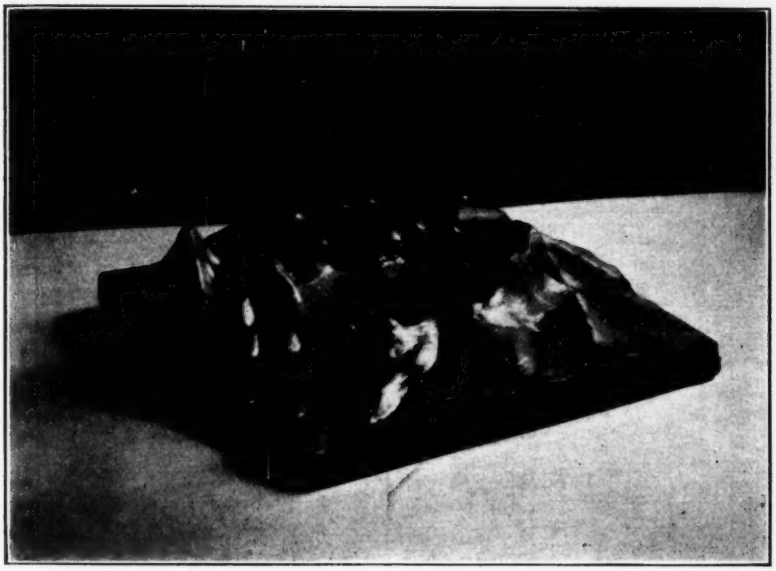


FIG. 3. A Model for use with the Map Apparatus

the sliding track of the attachment is fixed in position one inch from the left-hand ungraduated rim. In this position the point of the altitude gauge is allowed to traverse a section one-half inch within the left-hand margin of the model. Measurements are now made successively at suitable intervals along this first section of the model's surface, and the readings are recorded at the corresponding points upon special cross-section paper (See Fig. 4). One section completed, the sliding track is moved forward one inch, a like series of measurements carried out, and so on successively until all sections have been covered.

With the model still before him the student now begins drawing in the contours (See Fig. 4). After such corrections as the instructor can suggest have been made, the tank is filled with water to the 4-inch mark and roughly leveled. This water is now drawn off in successive half-inch

layers and each contour of the map is in turn compared with the temporary shore line of the model to which it should correspond. (See Fig. 5.)

The association of a definite form of model with each map which the student prepares, tends to supply the form element to the map in a way not possible where no similarly comprehensive view of surface form is

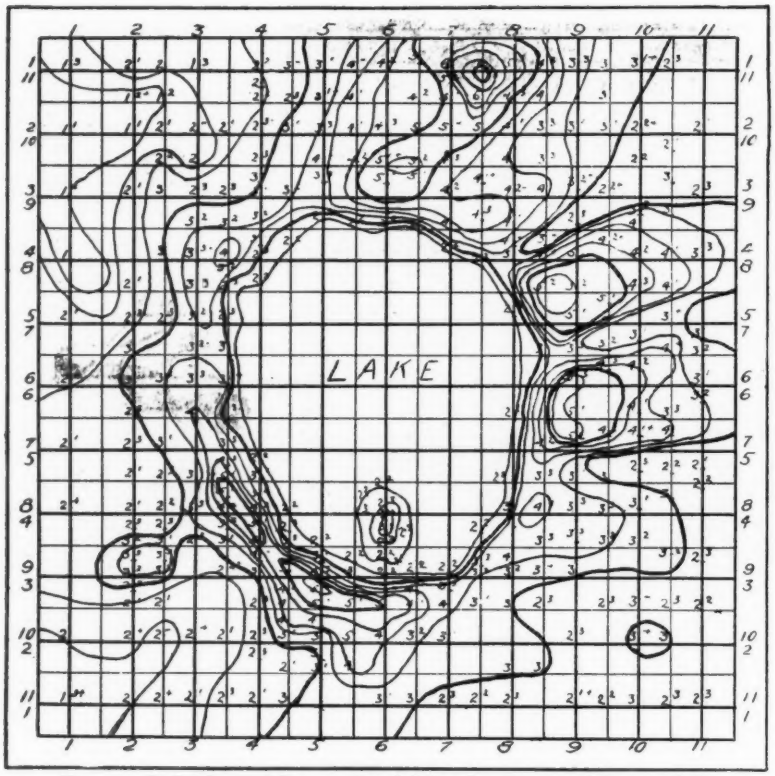


FIG. 4. A Student's Map on Special Section Paper of Crater Lake

obtained. The section paper used in the exercises being chosen with a unit of one half inch for each inch upon the model, affords further the fundamental idea of map scale. If alternate contours be first drawn in, a comparison of this preliminary map with the completed one will show how the shorter contour interval adds detail to the map.

Each apparatus is usually provided with two measuring attachments and so made available for use at the same time by a group of four students, two of whom record the measurements which the others record. The

sliding tracks may be quickly removed from the tank and reversed in position, which allows the students working upon one side to be free from interference from those working upon the other. The special map sheets are numbered in both directions in order to facilitate this double use of the apparatus. With six tanks a laboratory section of twenty-four students can thus be accommodated.

Use of the tank in modeling. To use the tank as a modeling ap-

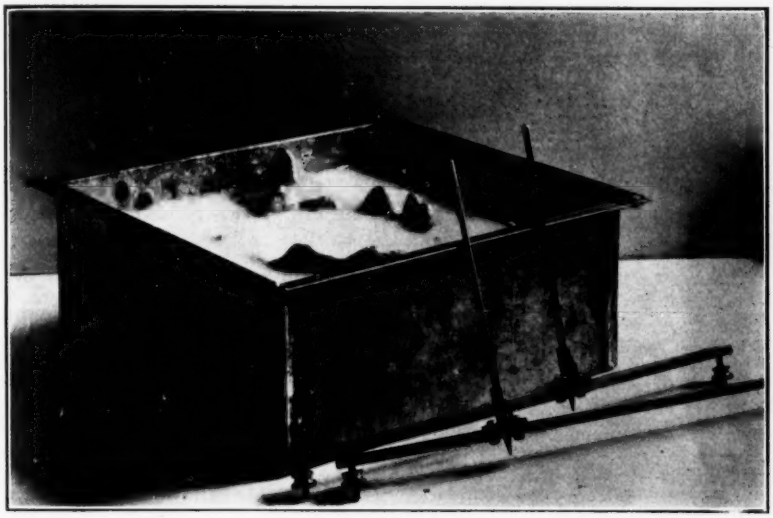


FIG. 5. The Apparatus in use for Testing the Contours of the Student's Map (In order to photograph the water-layer a little milk has here been added to the water)

paratus a piece of stout board eleven inches square is placed in the bottom and wedged in position by small blocks on all sides, the method used in fixing the position of models. A second tank may be fitted with a similar board and the contour map which it is desired to model, fastened to its upper surface by thumb tacks. For the time being the two tanks may be designated the model tank and the map tank respectively, and each is used with one measuring attachment only.

The process of modeling is in principle very simple. The attachment of each tank is set at the distance of one inch from the margin, and beginning in the usual way the altitude gauge of the map tank is set at the crossing of the first heavy contour. The altitude gauge of the model tank

is set in the same position upon its track and given the height demanded by the contour in question. Composite clay or other modeling material is built up to this height upon the board and shaped in approximate correspondence with the topography in the vicinity. The altitude gauges are then moved forward to the next crossing point of a heavy contour line (or as far as seems necessary) and the same process repeated. It is now possible to correct the model in the course traversed by the altitude gauge, and roughly to shape the country in advance. One section of the model completed in this fashion, the tracks are each moved forward one inch, or as far as is consistent with practical working, and the same procedure continued until the model is completed.

With use of a single tank essentially the same process may be carried out by use of a glass or celluloid plate a foot square on which a network of lines repeating in varying depths, quarter, half, and full inch intervals in either direction, has been drawn. Thumb tacks passing through perforations at the corners of this plate insure that its position is not changed in reference to the map while the work is in progress.

NOTE.—The apparatus above described is now manufactured and sold by Eberbach & Son Company of Ann Arbor, Mich.

EXHIBIT OF FOREIGN MAPS, ATLASES AND TEXTS.—The American Geographical Society will exhibit at their rooms, 15 West 81st Street, New York City, from December 21, 1908, to January 29, 1909, an interesting collection of foreign maps, and atlases, with a few texts.

This collection has been received from Germany, Austria-Hungary, France, Belgium, Switzerland and the United Kingdom and is representative of the best in the way of foreign wall maps and atlases.

After the close of the exhibit the American Geographical Society will loan the collection to any institution that will pay the freight on it from the previous place of exhibit. Here is a chance that ought to appeal to local geographical societies and normal schools.

The Society has published a sixteen-page annotated catalogue that will show the character of the collection. The Society should be addressed as above indicated.

GEOGRAPHY AT HARVARD UNIVERSITY

By Robert DeC. Ward
Harvard University, Cambridge, Mass.

General.—Instruction in geography at Harvard University is given in the Department of Geology and Geography, which forms part of the larger Division of Geology. The Division consists of two Departments, Geology and Geography, and Mineralogy and Petrography, and includes instruction in general and economic geology, physiography, meteorology and climatology, palæontology, mineralogy, petrography. From the beginning of systematic geographical teaching at Harvard, the study of the atmosphere has been thought of sufficient importance to warrant its inclusion in special courses devoted to that subject alone. The line between the study of the atmosphere and the study of the lands and oceans has therefore always, and wisely, been quite sharply drawn. The instruction in geography (taking this term in its broadest meaning) thus falls naturally under two heads, viz., (1) physiography proper, with a recent expansion along the line of economic or commercial geography, and (2) meteorology and climatology.

Physiography Proper.—Instruction in physiography proper is built up on an elementary half-course (Geology A) open to students of all grades, although it can be counted only toward the degrees of A.B. and S.B.[1] This course is required for admission to the more advanced courses in physiography. It gives a general, systematic view of the physiography of the lands and oceans, as presented in Davis' *Physical Geography*. Special emphasis is laid upon the place of the various physiographic forms in geographical classification and evolution, and upon their effects on human development. Laboratory work (3½ hours a week) familiarizes the student with geographical models, diagrams and maps of the various physiographic types in different parts of the world. A foundation is thus laid for more advanced work in physiography.

The Physiography of the United States and the Physiography of Europe are dealt with in two half-courses (Geology 6 and Geology 7, respectively).

[1] The instructors in the several courses are as follows: Geology A, C, 6, 9 and 20a, Assistant Professor D. W. Johnson. Geology B, 1, 2, 3, 19 and 20e, Assistant Professor R. DeC. Ward. Geology 20a, Professor W. M. Davis. Geology 20f, Professor A. L. Rotch. Of these courses, A, B, and C are intended primarily for undergraduates; 1, 2, 3, 6, 7, 9 and 19, for undergraduates and graduates; 20a, 20e and 20f, primarily for graduates. Details concerning hours, laboratory sections, etc., may be found in the Catalogue of the University, and fuller information is given in the descriptive pamphlet of the Division of Geology. Application for these publications should be made to the Publication Agent, Harvard University, Cambridge, Mass.

In order to take these, students are required to have passed Geology A. A knowledge of economic geography and of elementary geology is also recommended as valuable preparation. In Geology 6 and Geology 7 the subject is treated on the plan developed in the elementary course. The countries considered are divided, first according to their geological structure, and second, according to their geographical development. Attention is given to the relation of structure and form to conditions of human life, occupations, products, etc., and the laboratory work consists of the study of maps, and the preparation of diagrams illustrating selected physiographic features.

The advanced course in physiography (Geology 20a) is open to those who have passed satisfactorily in Geology A and Geology 6 or Geology 7. Opportunity for detailed study supplementary to that in the more elementary courses in physiography is here given.

Economic Geography.—Another elementary geographical course, recently established, deals with economic geography (Geology C). It is open to students of all grades, and counts for the degrees of A.B. and S.B. No previous training in any branch of geography is required. It is the aim of Geology C to present a brief account of the physical features of the earth which are of the greatest practical importance to mankind, and a more detailed account of the influence exerted by these features upon human development. This course is especially designed to meet the needs of the students in the new School of Business Administration, in furnishing them with a broad foundation on which their later studies in economics and allied subjects may rest. The laboratory work occupies 3½ hours a week. A somewhat more general half-course than Geology 6, above noted, is Geology 9, Geographic Influences in North America, which is intended for students who have taken the course in commercial geography (C). Elementary physiography and elementary meteorology are recommended, but not required, in preparation for it. The course gives a brief account of the principal physiographic features of North America, and a more detailed account of the influences which these features have exerted upon the commercial, industrial and political development of the country. The influence of the land forms upon the distribution and occupations of the people, and upon the location of transportation routes, cities, and political boundaries, is considered.

Meteorology and Climatology.—Meteorology as taught at Harvard runs along geographical rather than physical and mathematical lines. The subject therefore finds its appropriate place in the Department of

Geology and Geography, and the instruction deals very largely with geographical meteorology, or climatology. The principal end in view is to provide systematic instruction in the climatology of all parts of the world, with special reference to the relations of these climates to man. As at present arranged, the courses in meteorology and climatology are built up on an elementary half-course in meteorology (Geology B), and include, in addition, a half-course in general climatology (Geology 19); a half-course on the climatology of North America (Geology I); a half-course on the climatology of South America (Geology 2), this being chiefly a geographical course; and a half-course on the climatology of the Eastern Hemisphere (Geology 3). These intermediate courses lead to research work in meteorology (Geology 20e) and in climatology (Geology 20f).

The elementary half-course in meteorology is required of all who take the more advanced work. In this first course a half year is devoted to a study of the more important facts and theories in meteorology. Davis' *Elementary Meteorology* is used as a text-book. Four hours a week are devoted to laboratory work, which consists chiefly in the construction and study of weather maps and of meteorological charts and diagrams, practice in the use of the ordinary instruments and in the corrections of the observed readings; exercises in weather forecasting, and the like.

The climatology of North America (Geology 1) is a course designed to give a general view of the climates of this continent, especially suited to the use of students of physiography, forestry and medicine. It is, however, intended to be a suitable course of instruction for those who wish a broad outline of North American climatology as part of a general education. Special attention is paid to the United States. As a part of the laboratory work each student constructs a series of charts and curves of temperature, rainfall, relative humidity and cloudiness.

A course on the geography of South America (Geology 2) is on the borderline between physiography proper, economic geography and climatology. To take it, students (except those in the Graduate Schools) must have passed in both elementary physiography and elementary meteorology. This course presents, in broad outlines, a general view of the physiography, commercial geography, and climatology of South America as a whole, and, in greater detail, of the different political divisions individually. Special attention is paid to climatology, and to the control of climate over habitability, occupations, travel and transportation, etc. The basis of the discussion is, first, the larger geological and geographical divisions, and then, in a subordinate way, the political divisions. This method lays the most

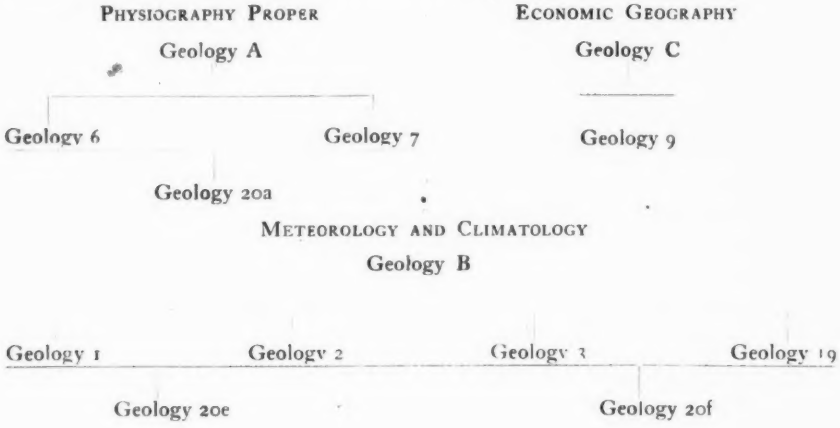
emphasis upon the purely geographic provinces. The political divisions are considered in order that the course may meet the needs of those who may later have business relations with South America, or may occupy consular or other official positions there. Laboratory work occupies 2 to 4 hours a week.

A course on the climatology of the Eastern Hemisphere (Geology 3) follows the same general lines as that on the climatology of North America, but the treatment is necessarily more superficial.

A half-course in general climatology (Geology 19) covers the ground of Hann's *Handbook of Climatology*, Vol. I, and of Ward's *Climate Considered Especially in Relation to Man*. This course is designed to give a knowledge of climatology in its broader aspects. It is recommended to those who intend to study medicine. Such subjects as the characteristics and hygiene of the zones; the acclimatization of the white race in the tropics; the life of man under the climatic controls in the different zones, and changes of climate, are here studied.

Two research courses are given. One (Geology 20e), a research course in meteorology, provides more advanced work in the subjects of courses 1, 2, 3, and 19, and is open only to those who have passed satisfactorily in those courses, or who have had equivalent preparation. The other (Geology 20f), a research course in meteorology, is given at Blue Hill Observatory. It is open only to advanced students who are thoroughly competent to take part in the special lines of meteorological investigation which are at present being undertaken at Blue Hill.

The general sequence of courses in geography at Harvard, and their relations to one another, may be seen in the following table:



NOTES

ILLUSTRATION OF SEASONS AND THE SOLAR SYSTEM AT THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY.—The exhibit in the Central Hall of the Second Floor which shows the time of day and the change of seasons has been modified and amplified so that now the four-foot globe representing the earth not only turns upon its axis once in twenty-four hours but also is made to revolve around the sun once a year with its proper motion and in its correct position. The light of the sun is represented by an electric stereopticon which casts a noon mark on the globe by means of the shadow of a line. This shadow at the same time shows the mean time for the longitude of New York City by means of subdivisions upon the equator. This exhibit has awakened a great deal of interest and is instructive in many ways additional to those mentioned.

The exhibit on the ground floor illustrating the solar system has been altered so as to be more comprehensive and instructive. The sun is now represented by an illuminated globe three inches in diameter, which brings the orbit of the earth just within the Foyer. The Foyer therefore now contains the whole of the orbits of Mercury, Venus and the Earth and part of that of Mars, while the adjoining exhibition halls contain the remainder of the orbits of Mars and parts of those of Jupiter and Saturn. The orbits are represented by circles of wire on which the days and months are indicated and along which the planets, shown as lights of proper size, are moved from day to day in correct position. This installation demonstrates graphically and on a satisfactory scale the relative positions of the members of the solar system as far as Mars on the day of observation, gives the morning and evening stars on that day and the reasons for their being such and illustrates other facts in astronomy that often are obscure to most people.

POPULATION OF CHILE.—The *Bollettino of the Italian Geographical Society* reports (August, 1908) that the official census of Chile, taken on November 28, 1907, shows a population of 3,248,224 inhabitants, an increase of 536,079 inhabitants since the census of 1895. Since 1835, the population has increased more than threefold, due almost entirely to natural growth, as immigration has been very small.

THE COMPARISON OF CLIMATES.—The Editor recalls vividly his own experience in going from the deck of a steamer down into the furnace room with the stokers; the temperatures then determined by him with the protected sling psychrometer were about as given by (1) and (2) in the

table. Another experience in the hot, dry air of a room heated by a Russian furnace gave observations (3) and (4). In the warm, dry air of sunny winter quarters in Washington, such readings as (5) and (6) were obtained.

Perhaps the most delightful conditions were those of (7), prevailing through the night in a strong southeast trade wind on the summit of Telegraph Hill on the Island of Ascension in February, 1890, where we could sleep without protection in a wind whose temperature scarcely varied from those of (7).

TABLE 1. INDOOR AND OUTDOOR HUMIDITIES OBSERVED BY PROF. C. ABBE

LOCALITY	DRY BULB	WET BULB	DEW POINT	RELATIVE HUMIDITY
Atlantic steamer:	° F.	° F.	° F.	Per cent.
(1) In the free air	91	85	83	78
(2) In the furnace room	120	91	83	33
Russia:				
(3) In the free air	0	2	20	33
(4) Furnace-heated room	120	65	20	1
Washington, D. C.:				
(5) In the free air	33	30	25	70
(6) Warm, sunny room	80	54	26	12
Island of Ascension:				
(7) In the free air	66	65	64	95

Most of these seven different conditions are agreeable to the writer with a proper adjustment of the wind velocity, but the sensations produced are widely various: thus (7) is restful and relaxative; (1) is perfectly indolent; (2), (4), and (6) produce a restless, uneasy, creepy, cold sensation as the skin becomes dry and harsh; one must drink much water and can scarcely do enough muscular exercise to counteract the dryness and keep the skin moist by a rapid circulation of the blood; (3) and (5) stimulate to exhilaration and to excellent intellectual work.

The following conditions: (8) Free air 55°, wet, 50° DP 45°, RH 73 per cent.; (9) Free air 60°, wet 52°, DP 45°, RH 68 per cent.; are admirable for outdoor exercise and the attendant intellectual stimulus, when the rapid circulation of the blood enables the brain to work rapidly, easily, smoothly, and with precision. One who works steadily for several hours in quiet until his food supply becomes low, the blood fills with effete matter faster than the purifying organs can eliminate it, and the circulation

becomes feeble—will usually find himself growing apparently colder, and will require the temperature of the room to be raised from 50° to 60° and perhaps to 70° or 80°, *i. e.*, to temperatures that would have seemed very uncomfortable at the beginning of his work.

These experiences are worthy of record and study. They will on the one hand elucidate the needs of our human physiology and on the other hand help us to more clearly define the relation between natural climates and the evolution of the peculiarities of the races of mankind.

The great variety of climates offered by the stations of our Weather Bureau and the frequent interchanges of observers suggest to us that each make a list of the stations at which he has lived, the length of time in years and months and the impressions produced on him as to the influence of the respective seasons of the local climates.—From *Monthly Weather Review,* September, 1908.

THE RELATIVE HUMIDITY OF OUR HOUSES IN WINTER.—In connection with the above note on Climates, it may be of interest to many readers to have an account of certain related observations carried out by Prof. R. DeC. Ward in Cambridge, Mass., eight or nine years ago.[1] His account and comments are given in slightly changed form here.

The observations.—The observations were made in the study of the observer by means of H. J. Green's Marvin sling psychrometer, and extended over three weeks of November, 1899, from the 3d to the 23d. The hours of observation varied, but the number was from two to five daily. Each observation comprised a record of the readings of the wet and dry-bulb thermometers, the condition of the out-of-doors weather, the amount of ventilation by means of the window, the temperature of the air coming from the furnace, and the stage of the water in an evaporating pan placed inside the register of the room.

The study in which the observations were made was heated by hot air from an ordinary hot-air furnace provided with the usual small evaporating pan. Inside the delivery register stood a vessel holding a little more than half a liter of water. This vessel had to be filled about once a day, although the rapidity of evaporation was found to depend so directly upon the amount of heat from the furnace that the time required to evaporate the water was very variable.

The observations have been summarized in the accompanying Table 1. In this table the values given in the outdoor elements have been taken from

[1] The results were first published in the *Boston Medical and Surgical Journal,* March 1, 1900; later revised and printed in the JOURNAL OF GEOGRAPHY, I, 1902, pp. 310-317.

the Richard thermograph and hydrograph exposed at the Harvard College Observatory, and are the recorded readings for the hours corresponding to the times of the indoor observations. These means for the outside air are thus not the true means for the day, but they serve the purpose of the comparative observations here presented.

TABLE 1. OBSERVATIONS ON INDOOR HUMIDITY, DURING NOVEMBER 1899, BY R. DEC. WARD

DATE	NUMBER OF OBSERVATIONS	INSIDE AIR		OUTSIDE AIR	
		MEAN TEMPERATURE	MEAN RELATIVE HUMIDITY	MEAN TEMPERATURE	MEAN RELATIVE HUMIDITY
		°	Per cent.	°	Per cent.
3	5	69	28	35	66
4	5	71	39	42	69
5	5	71	30	43	64
6	4	69	29	34	68
7	5	68	32	39	63
8	5	71	31	44	69
9	4	69	32	42	69
10	3	67	32	47	60
11	4	69	33	28	77
12	3	64	30	23	70
13	4	67	24	23	51
14	3	67	26	25	75
15	3	71	31	28	91
16	4	72	29	36	68
17	2	68	27	24	66
18	2	68	31	28	90
19	3	71	40	42	87
20	3	70	28	39	69
21	4	69	25	41	70
22	4	71	30	46	77
23	3	72	26	43	72
Means	.....	69	30	36	71

Notes to the table.—The maximum relative humidity outdoors was recorded on November 4 at 8 A.M. It had rained during the night, the outside air was very damp, and an easterly wind was blowing. The window was partly open and but little heat was coming from the furnace. The outside humidity was 92 per cent. and the conditions mentioned were

clearly favorable for a high degree of relative humidity indoors. At noon of this day the indoor humidity was still high, 45 per cent., but the weather was then beginning to clear, the wind gradually veering to the northwest. The window was still open.

The lowest relative humidity was 21 per cent., recorded November 23 at 10 A.M. The outside weather was clear, with a moderate northwest wind, and the relative humidity was 68 per cent. The windows were shut and there was a good supply of heat from the furnace.

The maximum relative humidity for a whole day was 40 per cent. recorded on November 19, a damp, rainy day, with overcast sky. The window was open throughout the day and there was moderate heat from the furnace. Outdoors the relative humidity averaged 37 per cent., which was exceeded on only two other days.

The minimum humidity for a whole day was 24 per cent. recorded on November 13, a clear, cold day, with moderate to brisk northwest wind, and on the outside relative humidity of 51 per cent. The windows were shut most of the day and the temperature of the room averaged 67°. The outdoor humidity was the minimum for any whole day during the period of observation.

The mean relative humidity of the outside air for the whole period was 71 per cent. or 40 per cent. in excess of the mean for the indoor air.

Discussion.—The relative humidity in a room is clearly the resultant of several variables, among which are the temperature and humidity outdoors, the amount of heat coming from the furnace, the amount of evaporation from the evaporating pans, the extent to which the room receives the outside air through the open windows, etc.

It appears from the data that the relation between the relative humidity of the air outside and inside is fairly close, increasing relative humidity indoors, and vice versa. The weather conditions during the absolute maximum of 45 per cent. and the daily maximum of 40 per cent. were, as has been seen, precisely such as would have led one to expect high humidity indoors. These same relations appeared distinctly on many of the other days of the observations. Thus on November 4, a change of wind from southeast to northwest, accompanied by clearing weather, was closely followed by a decrease of 34 per cent. in the outside relative humidity and of 6 per cent. indoors. Again, on November 11, a change of the wind to the east with rain, brought a rise in relative humidity of 15 per cent. outside and of 6 per cent. indoors. The next day, November 12, was rainy, followed by a clearing day, with northwest wind, and the relative humidity fell steadily

from 32 per cent. at 8 A.M. to 30 per cent. at noon, and to 28 per cent. at 6 P.M., the decreasing humidity keeping pace with the decreasing cloudiness and increasing velocity of the dry northwest wind. Outside, the relative humidity fell from 78 per cent. at the first observation to 69 per cent. at the second and 63 per cent. at the third. The windows were closed at the time of all the above changes.

Indoors climate vs. an arid climate.—The following Table 2 presents the relative humidities at a number of localities and these, when compared with the records within the study as just related, suggest some very interesting conclusions. They show clearly that the atmosphere of Professor Ward's study was drier than that of many desert regions, dry to the point of being dangerous to health as he shows. He finds that the strain which is put upon the body in the rapid readjustment required when we go from the high temperatures and desert aridity of our houses in winter, into a temperature 70° to 90° lower and a relative humidity of 70 to 100 per cent. is a greater one than we ought to repeat day after day and many times a day.

TABLE 2. LOW RELATIVE HUMIDITIES IN THE UNITED STATES

STATION	MEAN ANNUAL	MEAN MONTHLY MINIMUM
	Per cent.	Per cent.
Yuma, Ariz.	42.9	34.7 in June
Santa Fé, N. Mex.	44.8	28.7 in June
Pueblo, Colo.	46.2	37.6 in April
Death Valley, Cal.	23.0 for May to September, 1891	

In the dry interior of the great Eurasian Continent we find the following relative humidities:

Southwestern Siberia and western Turkestan have a mean of 45 to 50 per cent. in July. Yarkand, in eastern Turkestan, has a July mean of 47 per cent. In the arid region about the sea of Aral, Nukus has a June mean of 46 per cent. and a 2 P.M. June mean of 19 per cent. Petro-Alexandrovsk, 1.5° west of Nukus, and in the desert, has a June mean of 34 per cent. Kasalinsk, latitude 45.8° north, longitude 61.2° east, has a July mean of 45 per cent. The air is still drier in the deserts near the equator. Ghadames, Tripoli, has 27 per cent. in July, and 33 per cent. in August. The Kufra Oasis has 27 per cent. in August and a 3 P.M. August mean of 17 per cent. In the Punjab and northwestern India, Lahore has 31 per cent. and Agra has 36 per cent. in May.

It is generally acknowledged that the winter temperatures of our houses are too high, but the excessive dryness of the indoors air and consequent rapid evaporation from the skin combined make most of us uncomfortable unless the temperature is kept up to 70° or higher. Were the relative humidity of the house air higher, as it always is in the kitchens where steam is continually being sent into the air, then a temperature of 65° would be very comfortable. Such moisture can be introduced into the house air by increasing the evaporating area of the water-pans in the hot-air furnace or by placing similar pans over the super-heated steam coils of the steam-heated house.

Observations somewhat similar to the above were also made by Dr. H. J. Barnes[1] in his own office in Boston, and also in other buildings in Boston. By means of an apparatus of his own devising Doctor Barnes was able to maintain a mean relative humidity of 53 per cent. in his own office. This device placed over the delivering register of the hot-air furnace evaporated on the average four and one half quarts of water daily, and the resulting increased relative humidity kept the office comfortable at a temperature of 65°, while under the usual drier conditions the room must have a temperature of 70° or 71°.

TABLE 3. DR. H. J. BARNES' TABLE OF RELATIVE HUMIDITIES IN VARIOUS BOSTON BUILDINGS

PLACE AND TIME	HEATED BY	HUMIDITY MEAN RELATIVE	
		INDOORS	OUTDOORS
		Per cent.	Per cent.
City Hospital, 7 days, December, 1878.....		29	71
Office of Dr. Barnes, 7 days, January, 1896..	Indirect steam	27	73
Office of Dr. Ayer, 10 days, February, 1896..	Hot-air furnace	36	70
Women's Hospital, 8 days, February, 1896..	Indirect steam	24	71
City Hospital, 12 days, February and March, 1896	Indirect steam	38	74
Means	.....	31	71

—From *Monthly Weather Review,* September, 1908.

A CALIFORNIA CLOUDBURST.—In the upper reaches of San Emigdio Canyon, Kern County, Cal., cloudbursts have at many places stripped the mountain slopes bare of their forest cover and swept great trees and masses

[1] See "The Arid Atmosphere of Our Houses in Winter" in the *Trans. Amer. Public Health Assoc.,* 1898.

of rock many miles from their source. Just where the creek breaks from the hills is the hacienda of San Emigdio Rancho, and the superintendent of the rancho, J. S. Douglas, who has had ample opportunity to observe the cloudbursts, gave the following description to H. R. Johnson, of the United States Geological Survey.

"The cloudburst . . . issued from Cloudburst Canyon into San Emigdio Canyon about 8 miles above this ranch house. I had been expecting the occurrence, as the premonitory signs had been very pronounced for two or three days previously, viz., immense masses of white snowy clouds in the forenoons, changing in color to inky blackness in the afternoons, with the accompaniment of thunder. The weather was sultry, with occasional gusts of cool wind rushing *down* the canyon, an unusual occurrence during the day in summer time.

"Some time before the wave of mud and water made its appearance, probably fifteen minutes, its dull and heavy roar could be heard from up the canyon, quite distinct from and rising above all the other noises of the storm and reminding me of breakers against a rocky shore. As it issued from the narrow mouth of Cloudburst Canyon into the comparatively broad one of San Emigdio, it was accompanied by a cloud of dust occasioned by the breaking up of huge masses of dry soil torn from projecting points in its rush down the canyon.

"Through the dust glimpses would be had of great piles of drift with an occasional tree turning end over end . . .

"After reaching the main canyon it spread to a width of probably 200 yards, and after descending about one half mile came to a full stop, only to be succeeded in a few moments by another wave larger and swifter than the first. There was no dust about this or any of the succeeding waves, but immense masses of rock, many of which must have weighed several tons, were apparently dancing along, light as corks on the surface, being supported by the rocky mass beneath.

"This wave extended about one half mile farther down the canyon than the first, when it also came to a stop, having spread to the full width of the canyon (about one-fourth mile here).

"In a few moments another wave of mud swept by, followed by others at intervals of a few minutes, each succeeding wave getting thinner and travelling with greater velocity than the preceding ones, until finally in about half an hour it was mud no longer, but a steady rush of a yellow foaming torrent, at first probably 100 yards wide in the main canyon,

gradually reducing its width and increasing its depth and swiftness as it washed out a channel in the soft mud.

"In answer to your question as to the distance and size of rocks moved by cloudbursts, I will give you a description of one which lies on the bank of the creek close to this house. It is a sandstone bowlder which has come from 7 miles above and as near as it can be measured, owing to its irregular shape, gives the following dimensions: Height 8 feet, length 16 feet, width 12 feet. On the plains (the San Joaquin Valley) about 5 miles east of here, in Sec. 22, T. 11 N., R. 21 W., several masses much larger than this can be seen. These were brought down the Pleito Canyon by cloudbursts."

Commenting on this description, Mr. Johnson says:

"The interesting point about the cloudburst described above is its ebb and swing. It has further been learned that the first wave which brings down the coarsest débris often forms a dam at or near the canyon's entrance. It is as a result of the impact between the later waves and this débris dam that the greatest danger usually occurs, since the breaking of the dam at its weakest points usually results in the formation of new deep gulches in unexpected places, down which the liberated water and sludge rush toward the flatter marginal slopes of the fan, dividing and again dividing into smaller, less well-defined channels as they go. So far as observed, the end point of these cloudbursts is to be found in the thin irregular flows of mud left upon the lower slopes of the fans. These are in some places thick enough to obliterate the low bunchy grasses across which they have spread, and are characterized by a homogeneous, regularly cracked surface and an even, fine grain. Such thin, irregular mud beds are known by the well diggers of the region as "slickens."—From *Monthly Weather Review,* September, 1908.

THE INFLUENCE OF A GREAT CANAL. The facility with which trade moves to a new port, however, varies with a number of considerations. The momentum which older ports have acquired, the organization of the traders in the commodities imported and exported, and the weight and bulk—as well as the value of these commodities—have all to be taken into account. To illustrate these factors in the development of a port and at the same time to obtain some idea of the hinterland of the port of Manchester, we propose to examine the conditions determining the distribution of some of the chief commodities introduced into the country by the ship canal.

To Manchester people cotton is naturally the most interesting of these,

and it illustrates very well some of the difficulties which prevent the rapid development of the port. At first sight it might appear that it would be through Manchester that the great bulk of the raw material required in the cotton industry would be introduced into the country. Within twelve miles of the docks more than thirty-two millions of the forty-four millions of spindles in the United Kingdom are found, and to all the towns where these thirty-two millions are situated the rate for transmission of raw cotton by rail is less from Manchester than from Liverpool. To Bolton, for example, the rate including ship canal toll and dock charges is 10s. per ton from Manchester, while the cost via Liverpool is 13s. 6d.—a difference of 3s. 6d. To Oldham the rate from Manchester is 9s. 9d., while from Liverpool it is 14s. 8d.—a difference of 4s. 11d. To Stockport the charges are 8s. 10d. and 12s. 8d. respectively, the difference being 3s. 10d. It is unnecessary to multiply examples. Without reflection, therefore, one might be led to suppose that the places to which cotton goes from Manchester, are the places to which the rates are less than from Liverpool. But such a supposition would be very wide of the mark. With nearly seventy-five per cent. of the spindles of the United Kingdom in its immediate neighborhood, Manchester only imports about fourteen per cent. of the raw material which is used, while Liverpool imports about five times as much. For this there are several reasons, the chief being of an economic nature. In the first place there is the long-established supremacy of Liverpool as a great cotton market. That city thereby acquired a momentum which could not be seriously affected within the short period which has elapsed since the opening of the canal. At the beginning of that period, too, there was no cotton market in Manchester. The Manchester spinners had either to buy direct from the United States or go to Liverpool and buy in the market there. But there are great difficulties in buying direct from the United States. Few spinners are able or willing to buy the year's supply at once. If it is bought in instalments it is impossible to insure that the quality will be the same. When it is bought in Manchester through importers, the difficulties do not disappear. A comparatively small amount comes to this port, and although a spinner might be anxious to support the canal and at the same time effect a saving to his own pocket by purchasing in Manchester, he will frequently find either that there is no cotton on the wharf, or that it is not of the quality he requires. By going to Liverpool he is able to obtain just what he wants. Now, although this difficulty might be got over by the establishment of a spot market in Manchester—and such a

market has recently been started—a more serious obstacle has to be met. Much of the dealing in cotton is not for present, but for future delivery, and Liverpool merchants refuse to recognize the existence of Manchester. For example, if a dealer has one hundred bales of cotton in Manchester and sells them against futures held in Liverpool, they must be sent down to Liverpool. They are not tenderable in Manchester. The importer, therefore, who has sold futures to a Liverpool broker brings the cotton to that town, and from there it is distributed over the manufacturing area. Thus we have a case where geographical advantages and economic conditions stand in opposition and it is interesting to speculate on the ultimate result. Its growth so far has been steady and considerable. As compared with 121,336 bales of American cotton imported to Manchester during the season 1895-6, the quantity imported from America during the season 1907-8 amounted to 377,264 bales. The establishment of a spot market in Manchester will lead to an increase of buying in that town, and will encourage the American shipper to send his cotton there in the future to a greater extent than in the past. As the imports increase, Liverpool brokers will be forced to come to terms, and although buying and selling may continue to be done in Liverpool, much more of the actual commodity will find its way into the country by way of Manchester.

Egyptian cotton affords an interesting commentary of what has been said. Relatively a much larger amount of this goes to Manchester. One cause is that there is a good line of steamers carrying on the trade, but the chief reason is that many spinners, in order to get good cotton, buy at the beginning of the year. The Egyptian business also is simpler, and the larger houses of cotton merchants are chiefly in English hands, and are trustworthy. The spinner, therefore, has to buy early in order to get the quality which he wants, and having bought it he is sure of getting it. There is, thus, not the same reason for his going to Liverpool, and the raw cotton is brought to Manchester direct. At the present time one half of the Egyptian cotton used in Lancashire mills is shipped to Manchester. During the season 1907-8 this amounted to 216,570 bales.

—From *The Geographical Journal,* November, 1908.

Decisions of the United States Geographic Board. The Decisions of the United States Geographic Board (commonly known as the Board on Geographic Names), which have been made by the Board between July, 1906, and July, 1908, have been published in pamphlet form. The decisions mainly apply to the United States and its possessions and are in use by all government bureaus.

THE WORLD'S MINERALS. According to the statistics for the year 1906, as summarized in *Commercial America* for November, 1908, the total production of minerals for the year in question amounted to $4,500,000,000. Of this value the United States produced forty-two per cent. of the total, the United Kingdom eleven per cent. and Germany nine per cent. The value of coal produced exceeeded the combined values of gold, copper, iron, petroleum, silver, tin, nitrate of soda, lead, zinc, and diamonds for the whole world. The value of the coal produced was over four times that of the gold.

REVIEW

PHYSICAL GEOGRAPHY LANTERN SLIDES.—A Descriptive Catalogue of 1300 Slides Selected from Professor Tarr's Collection of 8,000 Illustrations of Physical Geography Phenomena. The Geography Supply Bureau, Publishers, Ithaca, N. Y.

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